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(54) Title: PRODUCT ASSEMBLY SYSTEM

(57) Abstract

There is described a method and a system for compiling a product specification. The invention has application in product manufacture wherein the product is made up of a number of optional components. The components are arranged in groups made up of a number of related components from which selection is to be made. The product and the system provide the user with means for making up the final product.

OPTION	SCREEN	GOTO SCREEN	GOTO CONDITION-ALITY	SCREEN CONDITION-ALITY	NOTES
M1	1	2		NOT IF B2	MODEL OPTIONS (CHOOSE 1)
M2	1	2		NOT IF B2	
M3	1	3	4 IF (B2 OR B4) OR T3	(ONLY IF B2 OR B4)	
				(NEITHER IF D1 OR D2)	
T1	2	3			TRIM QUALITY OPTIONS (CHOOSE 1)
T2	2	3			
T3	2	3			
B1	3	4		NOT IF M3	BODY COLOUR (CHOOSE 1)
B2	3	4	PREDICATES M3	NOT IF M1 OR M2	
B3	3	4		NOT IF M3	
B4	3	4	EXIT IF M1 AND T1		
D1	4	5		NOT IF M3	DASHBOARD OPTIONS (CHOOSE 0-3)
D2	4	5		NOT IF M3	
D3	4	5		NOT IF M3 AND B1*	
D4	4	5			
D5	4	5			
D6	4	5			
D7	4	5		ONLY IF M3	
D8	4	5		ONLY IF M3	
EXIT	5				SPECIFIC-ATION COMPLETE

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PRODUCT ASSEMBLY SYSTEM

Field of the Invention

This invention relates to a method of compiling a product specification and to a product assembly system.

Background of the Invention

Nearly all specifications of man-made objects are available in a wide variety, i.e. they include the choice of different features or options. Examples are the specification of an automobile where variety of the basic model can include the compulsory presence or absence of features according to the country of registration, as well as features such an alternative engines, automatic versus manual gearbox, colour and nature of the upholstery and other trim, body colour and a number of optional accessories. Another example is the specification of an insurance contract for commercial premises, where cover may be required for all goods, stock, raw material, work in progress, cash, building fabric and contents to guard against a choice of risks to various degrees of protection.

It is in the nature of such variety that the designer(s) of a family of car models, or indeed the designer(s) of the rules and regulations governing the pattern of an insurance contract which a given insurer will permit, builds into his kit of parts sufficient variety that many foreseeable combinations of market requirements are catered for. Yet it is also true that all possible combinations of variety are not available. For instance, some options come as alternatives to each

other - it is usually a case of either an automatic gearbox or a manual gearbox, covering goods-in-transit risk or not. Yet other options are truly optional, for example the listing of specific items of high value for which full replacement value might be required but which fall in predefined categories e.g. jewelry, pictures, coin or stamp collections, and, in the case of an automobile, additional fog lights or decals or choice of in-car entertainment. Sometimes options are truly optional but restricted to a maximum number of options within a class, for example extra instruments to fit on a necessarily restricted dashboard, or a maximum number of a very high value items listed without incurring an individually negotiated premium. Variety, after all, is a means of offering customer choice but without the expense of individual negotiation and costing in each case.

When a specification has been agreed by, say, a main dealer in the case of an automobile, or by an insurance consultant in the case of insurance, that specification has to be used to produce, in the case of an automobile, a bill of materials (structured list of parts) for the assembly line, and, in the case of an insurance contract, a contract policy consisting of the paragraphs of text and premium calculations appropriate to that particular specification. In both cases, the parts or paragraph appropriate to one particular feature of the specification may be totally independent of any other feature of the specification, but in other cases particular paragraphs or parts may be conditioned by having to take into account combinations of the features specified. Examples in the case of an automobile might be an additional fog light as opposed to the parts dictated by both automatic gearbox and a more powerful engine having been chosen. In the case of an insurance

contract, the nature of the business might dictate a special sub-clause if perishable goods in transit were also insured, for example.

The order in which the features/aspects/options of a specification are described is not relevant - it is the whole set of such descriptors which makes up a specification. However, the order in which features are presented for choice by a client is often dictated by convention or usual practice. Thus in the case of a complicated manufactured product, it would be natural for the design engineer(s) to consider the major variations first, then less major and finally the more minor variations. That degree of major-to-minor is not, however, necessarily correlated with the resultant complexity of components to be associated with each variant. In the case of an insurance contract, each major insurer has developed over the years familiar sequences of opening up the options by groups of options and successions of groups, as well as proffering more detailed sub-options when a more major option has been chosen.

It is this complexity of options structure, which rarely conforms to what is known mathematically as a tree structure, which has bedeviled the derivation of a highly specialised computer package for capturing option structure and hence specification choice. The problem is not mathematically trivial, being difficult to specify in the appropriate branch of mathematics known as propositional logic. Any fixed structure of options can be represented in a wide variety of approaches to capturing the logical connections, but in the two applications areas of manufactured product and insurance contracts represented above, and in many other applications, there is often a need in time to modify the

logical connections and to introduce new options with their own logical connections. Such updating and maintenance can tax the effort required unless the original design has been conceived with that maintenance and updating requirement in mind. Yet again, a common problem in both the application areas designated, and others, is the need to maintain dated versions of both the options structure and the database containing "parts" appropriate to each dated version of the option structure. This is a particularly strong requirement for manufactured products given the necessity to recreate a true bill of material for each serially numbered product variant, and is increasingly recognised as a complete traceability requirement for all products and services under ISO 9000.

Summary of the Invention

One aspect of the invention provides a method of compiling a product specification by selecting from a plurality of optional components arranged in groups, each group comprising a plurality of related components of which any number from a predetermined minimum to a predetermined maximum may be selected, the availability for selection of at least some of the components being dependent on those components already selected, the method comprising:

(a) displaying a list identifying the available groups of components, and, in response to selection of a group;

(b) displaying a list identifying the components in the selected group;

(c) in response to selection of a component, determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected; and

(d) either, displaying a list identifying the components for selection in said next group and then repeating step (c) or, if no further components remain to be selected, outputting a specification comprising all the components selected.

Another aspect of the invention provides a product assembly system, comprising a computer housing display means, processing means, data input means, and assembly means controlling the assembly of the product, the computer having stored therein data representing a plurality of optional components arranged in groups, each group comprising a plurality of related components of which any number from predetermined minimum to a predetermined maximum may be selected, and data identifying the availability for selection of the components in dependence on those components already selected, and the processing means being controlled by a program to process the data in order to perform the following steps:

(a) displaying via the display means a list identifying the available groups of components, and, in response to selection via the data input means of a group;

(b) displaying via the display means a list identifying the components in the selected group;

(c) in response to selection of a component via the date input means determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected; and

(d) either, displaying via the display means a list identifying the components for selection in said next group and then repeating step (c) or, if no further components remain to be selected, outputting to the assembly means a specification comprising all the components selected to control assembly of the product.

Preferably, a step (b1) follows on from step (b) and comprises determining which of the other components in the group may be selected in combination with the selected component or components and step (d) comprises either displaying a list identifying the said other components in the group and repeating steps (b1) and (c) or, if no components remain in the group, determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected.

Preferably, the computer also has stored therein data representing sub-components and the requirements such sub-components in each component, and the processing means is controlled by the program to identify for each selected component which sub-components are required and to output to the assembly means a specification in which the sub-component for each component are set out.

It will be appreciated that the components may be parts of a manufactured product such as a motor vehicle, or components (clauses) of an insurance policy or the like.

It follows from the above that a packaged program to handle options structure has a minimum four basic elements. First and foremost, it has an options-plus-linkages database (the OLDB), and directly associated with it the second element, which is the parts and qualifiers database (the PQDB). The third element is that of the option screens interface (the OSI), and the fourth element is that of an algorithmic engine (the AE) which performs any type of arithmetic and numeric manipulation/comparison required in an application.

A final element consists of various utilities, including editing, printing, screen formatting features, operating system linkers etc.

The relationship between the four major elements is critical to the efficiency of the system both in operation and in maintenance. Fundamentally the user interface, i.e. screens presented for options choice, is entirely generated from the options and linkage database. The reason for this is simple - any changes to the OLDB (a not infrequent occurrence in the initial attempts to capture a given option structure as well as being occasioned when options or linkages are changed) are likely to change either or both of the order of screen presentation or screen contents. Put another way, screen presentation is relatively arbitrary, the options linkage database is not. In a similar way, screens requiring data which have to be manipulated numerically or mathematically can have associated dedication of keys,

that dedication being specific to screens. On the other hand, the parts database is independent of the options database, except that there is a one-to-one correspondence between the part qualifiers (though not if multiple qualifications are required) and the features (qualifications) which are presented as options. Integration of the main elements is achieved by various verification techniques and positive prompting if any editing change is not completed in the required detail.

Incorporated in the utilities element are facilities for adding permanent specific textual or other information, plus import/export facilities via ASCII files - in this way the options system can be embedded into other administrative systems.

Example

Reference is made to the Figure, which illustrates diagrammatically the database structure usable in one example of the product assembly system of the invention. The basic structure consists of a list (though shown as ordered by screen presentation number for convenience), and the essential fields of information are under the headings OPTION, SCREEN, GO TO SCREEN, GO TO CONDITIONALITY and SCREEN CONDITIONALITY for each OPTION item on that list.

Taking the first group of MODEL OPTIONS, it will be observed that there is a choice of one and one only of the three MODELS labelled M1 M2 M3 (there is no significance though perhaps convenience in this labelling M1 M2 M3). The choice pattern, in this case one and one only, is

achieved by a familiar device or algorithm setting the maximum and minimum number of choices to be made on a screen when presented for choice, in this case MIN=MAX=1.

The whole group of M1 M2 M3 options is conveniently presented on a single screen (or screen continuation) and if for convenience this screen is presented first in choosing the various options which go to make up a specification, then the third field of information, the GO TO SCREEN, indicates the SCREEN which will be presented if a given choice is made. Thus if M1 is chosen, SCREEN 2 will be presented, likewise if M2 is chosen. However, if M3 is chosen, the example shown indicates that the next screen to be presented is SCREEN 3, and this caters for the possibility that a choice of MODEL M3 totally predicates the choice of the TRIM options T1 T2 T3. It is not necessary to indicate this in the options - linkages list or database, since M3 in this case is logically equivalent to M3 AND B3 (for example).

The fourth field of information GO TO CONDITIONALITY modifies the GO TO SCREEN field dynamically as the specification (string of options defining the specification) is evolved i.e. chosen. For example, the GO TO CONDITIONALITY field associated with BODY COLOUR B4, states that if M1 and T1 have already been chose, choice is no longer available in the group of options known as DASHBOARD OPTIONS which as a result of the choice of M1 AND T1 AND B4 has now become predetermined. The first advantage of the use of a GO TO CONDITIONALITY field is that multiple representation of options via their multiple representation on different screens can be totally obviated. In other words, options which can be arrived at as a result of different previous sub-

specification paths need only been listed once in the options-linkage list. This has clear cut advantages both for updating and maintaining that list.

The second advantage of the GO TO CONDITIONALITY field is associated with the presence also of the fifth field SCREEN CONDITIONALITY. This fifth field by itself has advantages. The first advantage is that should a user wish to determine his options in a different order than that suggested in the original list i.e. MODEL followed by TRIM followed by BODY COLOUR followed by DASHBOARD OPTIONS (a different order of choice being made available by choosing from a list of option groups before beginning individual option selection), then those options which are not compatible with individual option choices as they are made will now not appear. In the example illustrated a choice of B2 by itself will predetermine M3, as would a choice of B4. This would in the illustrated example immediately lead to screen 4, having itself predetermined a choice of TRIM.

The second advantage of the SCREEN CONDITIONALITY field is well illustrated by such entries as associated with D1, D2, D3, and D7 and D8. In these cases the actual composition of the subgroups can vary dynamically as choices evolve.

Examination of the illustrated Example shows internal self-checking of the captured predicate logic at work. For example the GO TO CONDITIONALITY field associated with M1 and M2 are mirrored in the GO TO CONDITIONALITY field of B2. A counter example is that of the GO TO CONDITIONALITY field of D3, asterisked*, which is not consistent with

that of M3 and that of B1. In the case of complex rules and regulations, the detection of such inconsistencies is of great importance in the order that a specification can be completed without reference to authority external and higher than that associated with the specification system laid down.

It should be noted that both the go to conditionality and the screen conditionality fields can handle multiple conditionalities. It should further be noted that changes to screen composition may well force changes to the min-max choice parameters associated with that screen, and since this can be incorporated algorithmically, this adds additional power and flexibility to the representation of complex logical relationships and choice.

CLAIMS

1. A method of compiling a product specification by selecting from a plurality of optional components arranged in groups, each group comprising a plurality of related components of which any number from a predetermined minimum to a predetermined maximum may be selected, the availability for selection of at least some of the components being dependent on those components already selected, the method comprising:

(a) displaying a list identifying the available groups of components, and, in response to selection of a group;

(b) displaying a list identifying the components in the selected group;

(c) in response to selection of a component, determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected; and

(d) either, displaying a list identifying the components for selection in said next group and then repeating step (c) or, if no further components remain to be selected, outputting a specification comprising all the components selected.

2. A method according to Claim 1, wherein a step (b1) follows on from step (b) and comprises determining which of the other components in the group may be selected in combination with the selected component or

components and step (d) comprises either displaying a list identifying the said other components in the group and repeating steps (b1) and (c) or, if no components remain in the group, determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected.

3. A product assembly system, comprising a computer housing display means, processing means, data input means, and assembly means controlling the assembly of the product, the computer having stored therein data representing a plurality of optional components arranged in groups, each group comprising a plurality of related components of which any number from predetermined minimum to a predetermined maximum may be selected, and data identifying the availability for selection of the components in dependence on those components already selected, and the processing means being controlled by a program to process the data in order to perform the following steps:

(a) displaying via the display means a list identifying the available groups of components, and, in response to selection via the data input means of a group;

(b) displaying via the display means a list identifying the components in the selected group;

(c) in response to selection of a component via the date input means determining the next group to be selected according to the components already selected and determining which components in the next group are

available for selection in combination with those already selected; and

(d) either, displaying via the display means a list identifying the components for selection in said next group and then repeating step (c) or, if no further components remain to be selected, outputting to the assembly means a specification comprising all the components selected to control assembly of the product.

4. A system according to Claim 3, wherein a step (b1) follows on from step (b) and comprises determining which of the other components in the group may be selected in combination with the selected component or components and step (d) comprises either displaying a list identifying the said other components in the group and repeating steps (b1) and (c) or, if no components remain in the group, determining the next group to be selected according to the components already selected and determining which components in the next group are available for selection in combination with those already selected.

5. A system according to Claim 3 or 4, wherein the computer also has stored therein data representing sub-components and the requirements for such sub-components in each component, and the processing means is controlled by the program to identify for each selected component which sub-components are required and to output to the assembly means a specification in which the sub-component for each component are set out.

6. A system according to Claim 3, 4 or 5, wherein the assembly means is a product assembly line, the product specification being used to

control delivery of components and/or sub-components to the assembly line and assembly of the product from said components.

7. A system according to Claim 3, 4 or 5 wherein the assembly means comprises a document printer to print a document comprising the selected components.

8. A product assembly system, substantially as described with reference to the Figure.

OPTION	SCREEN	GOTO SCREEN	GOTO CONDITION-ALITY	SCREEN CONDITION-ALITY	NOTES
M1	1	2		NOT IF B2	MODEL OPTIONS (CHOOSE 1)
M2	1	2		NOT IF B2	
M3	1	3	4 IF (B2 OR B4) OR T3	(ONLY IF B2 OR B4)	
				(NEITHER IF D1 OR D2)	
T1	2	3			TRIM QUALITY OPTIONS (CHOOSE 1)
T2	2	3			
T3	2	3			
B1	3	4		NOT IF M3	BODY COLOUR (CHOOSE 1)
B2	3	4	PREDICATES M3	NOT IF M1 OR M2	
B3	3	4		NOT IF M3	
B4	3	4	EXIT IF M1 AND T1		
D1	4	5		NOT IF M3	DASHBOARD OPTIONS (CHOOSE 0-3)
D2	4	5		NOT IF M3	
D3	4	5		NOT IF M3 AND B1*	
D4	4	5			
D5	4	5			
D6	4	5			
D7	4	5		ONLY IF M3	
D8	4	5		ONLY IF M3	
EXIT	5				SPECIFIC-ATION COMPLETE

INTERNATIONAL SEARCH REPORT

Interna l Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	GB,A,2 264 797 (CURNOW) 8 September 1993 see the whole document	1-8
X	WO,A,91 00576 (EXPROCAD) 10 January 1991 see page 4, line 12 - line 22	1-8
X	INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH. vol. 25, no. 11 , November 1987 , UK pages 1645 - 1658 E.A. VAN VEEN & J.C. WORTMANN 'Generic bills of material in assemble-to-order manufacturing' see page 1654, line 15 - line 23	1-8
X	US,A,5 241 464 (GREULICH ET AL.) 31 August 1993 see column 3, line 23 - line 31	1-8

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 April 1994	24. 05. 94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 520 927 (IBM) 30 December 1992 see the whole document	1-8
A	WO,A,93 06555 (ANDERSEN CONSULTING) 1 April 1993 see page 9, line 12 - page 10, line 9; claims 10,58	1-8

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern al Application No
PCT/GB 93/01866

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		GB-A-	2234097	23-01-91
US-A-5241464	31-08-93	NONE		
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		AU-A-	2672492	27-04-93